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Contextual Inquiry of a 100 Aircraft Regional Airline Systems Operation Center

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GEORGIA TECH COGNITIVE ENGINEERING CENTER

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Thanks to Steve Altus at Jeppesen for coordinating my visit and for the SOC personnel for their patience and enthusiasm for their jobs.

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Executive Summary

A contextual inquiry was conducted at the Systems Operational Center (SOC) of a Regional Airline with approximately 100 aircraft from the 24-27th of July 2006. A total of 30 hours of direct observation were conducted with various members of the SOC Staff including the Director of Systems Operations (DSO), the Manager of Customer Operations (MCO) and the Line Maintenance Planner (LMP). During the inquiry a wide variety of situations occurred: unscheduled maintenance delays, estimated ready time slips, a bird strike, a disruptive passenger requiring a cabin lock-down, a declared emergency due to oil temperature, taxi delays, weather delays, and brake-cooling delays.

The vast majority of these situations were handled as if they were no different from routine operations; however, there were moments when the SOC personnel were pushed to their professional limits and the introduction of any other, even minor, issue could have caused severe disruptions to the schedule. The majority of problems faced by the the airline's SOC on a daily basis came from lack of resources (planes and flight crew) and from inclement weather. During the inquiry, between 4-12 planes ($\sim$6-9% of the fleet) were consistently out for unscheduled maintenance. Additionally, one one day during the observations 24[1] flight crew who were scheduled to fly were unavailable. Unlike other airlines, ATC restrictions are not often an issue for this airline, although station curfews in southern California do place an additional constraint on the schedule recovery process.

Beyond the resource shortages and the inevitable weather interruptions, the majority of problems stemmed from software tools which limited the effectiveness of the SOC personnel. For example, several of the major software tools depend on different databases with limited connectivity, creating discrepancies between systems and requiring information to be entered multiple times. Additionally, the VisOps tool, used a primary measure of airline schedule adherence, does not support the logging of problems/issues, solution generation through the use of either advanced sort and search features, optimization algorithms and solution sharing. To make best use of the software tools on hand, especially VisOps, larger computer monitors are needed. The resolution at which the software tools must be set for visibility limits their usefulness with 19 inch monitors.

Finally, none of the staff interviewed could indicate to any consistent quantitative feedback regarding the relative merits of their decisions on overall system performance. Instead, they often faced inquires about specific decisions which may only make sense when viewed from the overall context of the situation. Appropriate feedback could be provided as summary statistics regarding number of fights canceled, average delay and daily operational costs, which could be generated and displayed to them automatically.

[1]This is the number of individuals on no-fly status for just the 27th of July 2006. A total of 90 individuals were on the no-fly satus, but the duration of their status was longer than a single day.

Nomenclature

SOC Systems Operation Center

DSO Director Systems Operations

MCO Manager for Customer Operations

LMC Line Maintenance Planner

MC Maintenance Coordinator

MEL Minimum Equipment List

DMP Daily Maintenance Planner

ACARS Aircraft Communication Addressing and Reporting System

MOM Maintenance Operation Manager

1 Introduction to Airline

This airline is a regional airline, operating primarily along the western third of the United States and Mexico. They have a one major hub and one minor hub in the pacific northwest. From herethey service the West Coast of North America and Mexican markets. They carry both passengers and cargo, and derive approximately 4% of their revenue from freight.

At the time of the contextual inquiry this airline had approximately 110 aircraft split between MD-80s, and Boeing 737-200s, -400s, -700s , -800s and -900s. All of the Boeing aircraft had compatible flight deck configurations which allowed the airline to operate with only two crew fleet types. The airline had approximately 500 scheduled flights per day. It is not known how many pilots were either actively scheduled or on reserve on any given day.

2 SOC Organization and Personnel

The Systems Operational Center (SOC) at this airline is organized into two main rooms. Within these rooms there are five functional areas: Operations Control, Dispatchers, Flight Crew Scheduling, Cabin Crew Scheduling, and Maintenance. Each group is co-located around a group of desks, and, with the exception of the maintenance group, can all be seen by the Director of Systems Operations (see Figure 1).

The operations control group consists of three individuals: the Director of Systems Operations (DSO), the Manager of Customer Operations (MCO) and the Line Maintenance Planner (LMP). These three individuals form the core of the SOC decision making, and while they do not refer to themselves as the operations control group, this title is useful for the purposes of this report. The DSO is has ultimate responsibility for the operation of the airline during his shift. He has final authority over when to delay, cancel or add flight segments. He is aided by all of the individuals in the SOC, particularly the LMP and certain individuals outside of the SOC. The LMP is tasked with keeping all of the aircraft legal to fly by ensuring that they undergo their scheduled maintenance on time. Often, because of the limitations of the current tools and because of the limited number of spare aircraft, the LMP is called on to double check all flight swaps and cancelations to ensure they maintain a coherent maintenance schedule. Consequently, he is also asked to implement most of the swaps and cancelations. The DSO is also aided by the MCO, who serves as an additional set of eyes and ears for the DSO. The MCO is tasked with representing the customer in all decisions taken at the SOC. Secondarily, she also serves as the lead communications hub to all of the stations. The MCO keeps the stations informed of changes to the posted schedule prior to public posting, and receives information from the stations about weather conditions and possible issues, often passenger related. He frequently devises solutions – swaps, delays and cancelations – to problems that come through to the DSO and then suggests them to the DSO and LMP. The roles of the members of the operations control group are summarized in Table 1.

The dispatch group consists of five dispatchers (labeled A-F, minus “D”) and one chief dispatcher (occupying the “D” desk). The dispatchers are tasked with creating and filing flight plans for each flight. The chief dispatcher is additionally tasked with representing the airline in all dealings with air traffic control (ATC). The dispatchers face additional challenges due to the difficult approaches and poor weather conditions often encountered at outer stations. These challenges include verifying pilot experience level for different visibility conditions and double checking minimum equipment lists (MELs) for flights into stations with high-precision navigation aid requirements such as found in some of their more remote stations.

The flight and cabin crew group consists of a Pilot Scheduler and a Crew Scheduler who are responsible for maintaining the schedule for flight and cabin crew that day. Additionally, there are a number of additional personnel responsible for pilot and crew check in and covering individuals unable to work their shifts.

Table 1. SOC Operations Control Group Roles

Position	Roles
Director of Systems Operation DSO	
	Coordinator of planned schedule change
	Facilitator for scheduled recovery task assignment
	Notifier of upper management on issues of importance
	Schedule monitor for schedule deviations or probable schedule deviations
	Creator of possible schedule recovery plans
Manager of Customer Operations (MCO)	
	Coordinator of SOC-station operations
	Aid for DSO with problem solving
	Resource for citations
	Advocate for customers
Line Maintenance Planer (LMP)	
	Maintainer of aircraft maintenance schedule and thus legality
	Inspector of recovery plan
	Implementor of recovery plan
	Coordinator of daily maintenance planning

The maintenance group is by far the largest contingent in the SOC, occupying an entire room. They consisted of a Maintenance Operations Manager (MOM), two Maintenance Coordinators (MCs), Daily Maintenance Planners (DMP), and a number of other individuals supporting the maintenance efforts – such as a parts procurement officer. The MOM is tasked with the smooth and effective maintenance operation. The MCs are tasked with handling calls from the line maintenance staff regarding the issuance of MELs and the status report of ongoing, unscheduled repairs. They are further responsible for keeping the rest of the SOC staff informed of unscheduled maintenance issues and ready times.

3 Physical Models

The purpose of the physical model is to depict the physical environment in which the work takes place and to detect any physical barriers to productive work. Figure 1 is the physical model the SOC. The SOC is divided into two areas by a wall that extends two-thirds into the room. The main area contains the operations control group, the flight and cabin crew groups and the dispatchers. The second area contains the maintenance group. The main area is organized according to the four groups, with each group essentially getting a bank of work stations, and with the Pilot Scheduler and the Crew Scheduler occupying a desk in the operations control group, each work station is represented in the model as a box. As illustrated in Figure 1, the DSO can see most of the SOC personnel sitting in the main area. Because of the layout the DSO is also able to speak to most of the individuals seated at the operations control group bank of work stations. This is extremely useful to the DSO as it minimizes the amount of time he or she must spend on the phone with the Pilot and Crew Schedulers; often she is able to simply ask them aloud to find a crew or ask for a status report. Also, due to the close proximity to the LMP and the MCO, the DSO's conversations can often be overheard by both the LMP and the MCO. This is also advantageous as it helps to minimize the amount of time spent directly explaining a situation to either the LMP or MCO; often they are able to anticipate issues or problems because of their proximity.

Unfortunately, it is not possible to allow everyone to sit within earshot of each other. Both the dispatchers and the maintenance personnel are situated away from the DSO and the operations control group. The distance between the DSO and these groups has on occasion caused some breakdowns in communication as dispatchers will neglect to inform the DSO of a late departure, or of the reason for the late departure, thus requiring that the DSO notice the schedule discrepancy herself and call to inquire about it. Similarly, it has lead to many phone calls to the maintenance group asking after aircraft that maintenance has not updated in several hours to better understand the accuracy of the posted ready time. Sometimes this takes place while an MC is on the phone with line maintenance attempting to ascertain exactly that information.

The majority of the work stations are similar in nature. As the workstations are manned 24 hours a day by two or three shifts of people, most of the customization of the workstations is limited to the software settings and on screen placement of various software tools. However, in order to understand the basic layout of a workstation and how this layout affects the work undertaken, Figure 2 represents an average workstation and Figure 3 represents the DSO's work station, which differs from the standard workstation. The standard workstation consists of a U-shaped desk area. On the desk area are located two 19" flat-panel monitors hooked into a single computer such that the two monitors can be accessed using a single keyboard and mouse. In addition to the computer hardware located on the work station, there are standard office tools such as staplers, tape dispensers, pens and pencils in a cup, and a phone. The phone system consists of a handset which plugs into a non-standard jack affixed to the underside of the desktop and a 15" touch-screen monitor. The phone system is accessed through the touch-screen monitor and an light illuminates to

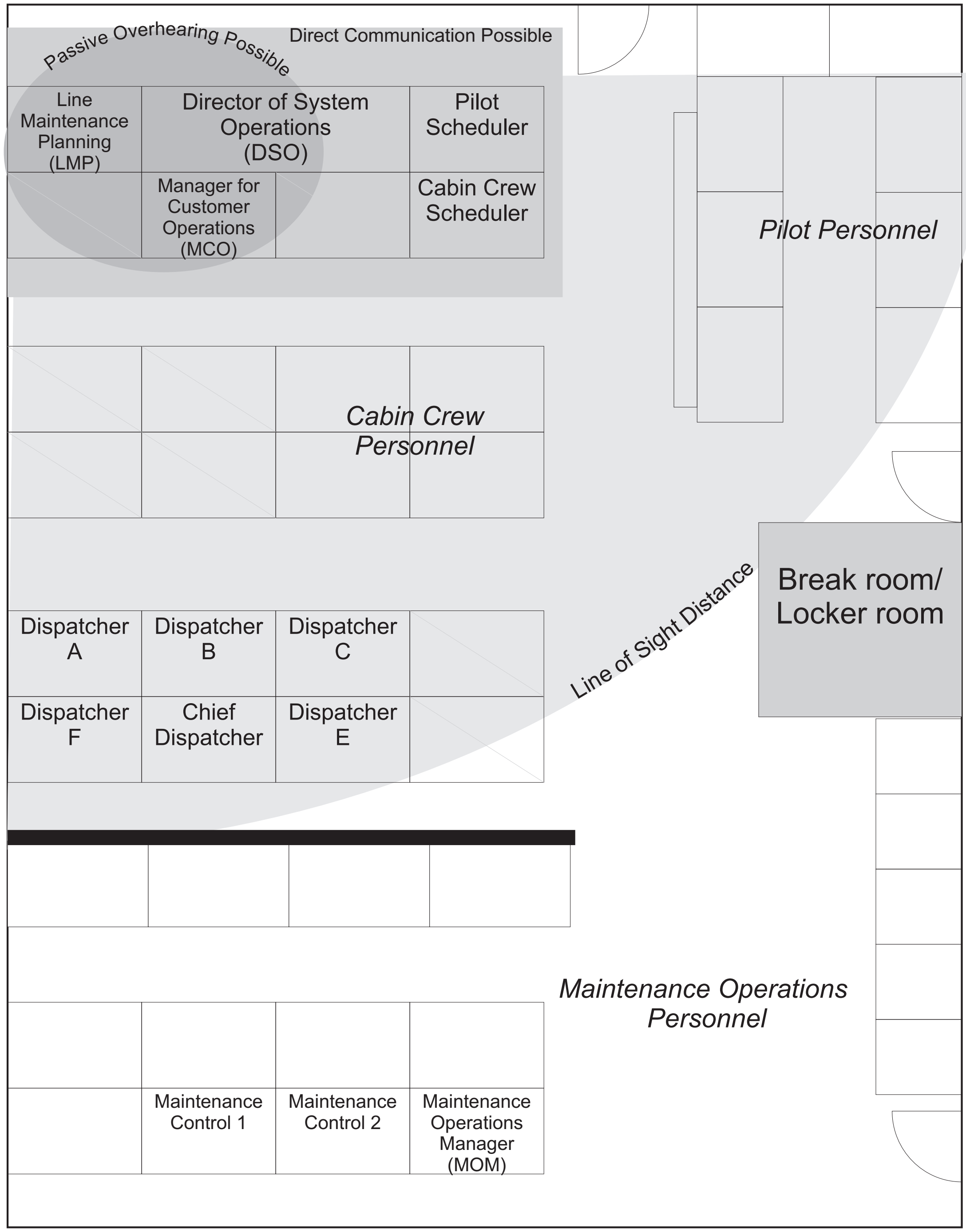


Figure 1. Physical Model of SOC

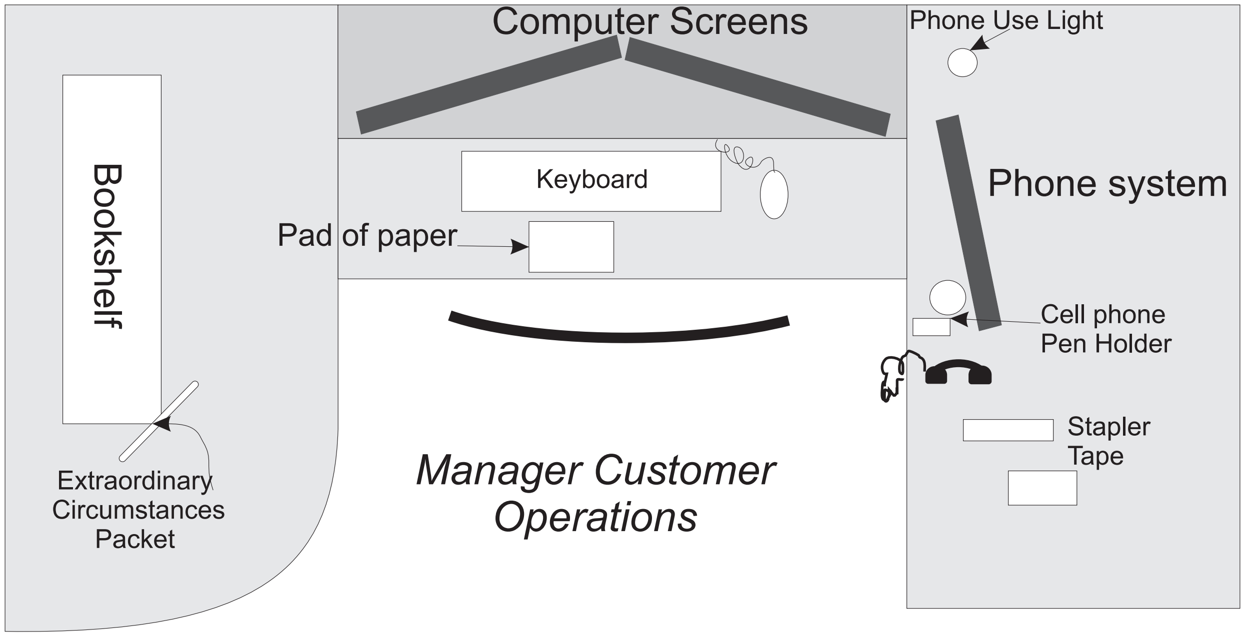


Figure 2. Physical Model of MCO's Desk

indicate both incoming calls and an active phone line. In addition to the land-line phone, most employees have their company mobile phone charging at their work station. Because the nature of the work involves accessing reference materials, many of the work stations have single level bookshelves. Among these reference materials, the MCO had a special packet that was used by the customer service representatives at the stations in the case of exceptional circumstances. This packet includes a checklist and a pack of post cards for customers to fill out on the spot. Additionally, many of the SOC personnel keep a pad of paper (the size varies by individual) and pen handy to jot down information and reminders to themselves.

The one deviation to the standard work station is the DSO's work station. It occupied the space of two standard work stations and was being outfitted to accommodate three DSOs. At the present, however, it was only home to a single DSO, who used the extra monitor space to display more software tools. Since the DSO's primary keyboard and mouse only controlled the closest two monitors, the secondary monitors were set up to display the aircraft situation display (ASD) and the GateSheet, both of which were used by the DSO to passively monitor the airline and infrequently to actively investigate an anomaly. The DSO also had a set of small speakers which he could patch into the different airline radio frequencies primarily used by baggage handlers, maintenance chiefs and ramp personnel. In addition to the normal assortment of office supplies, the DSO sat adjacent to a printer which she used often to pass a possible flight swap to the LMP to check and implement. The DSO also kept information regarding the critical maintenance for the day,

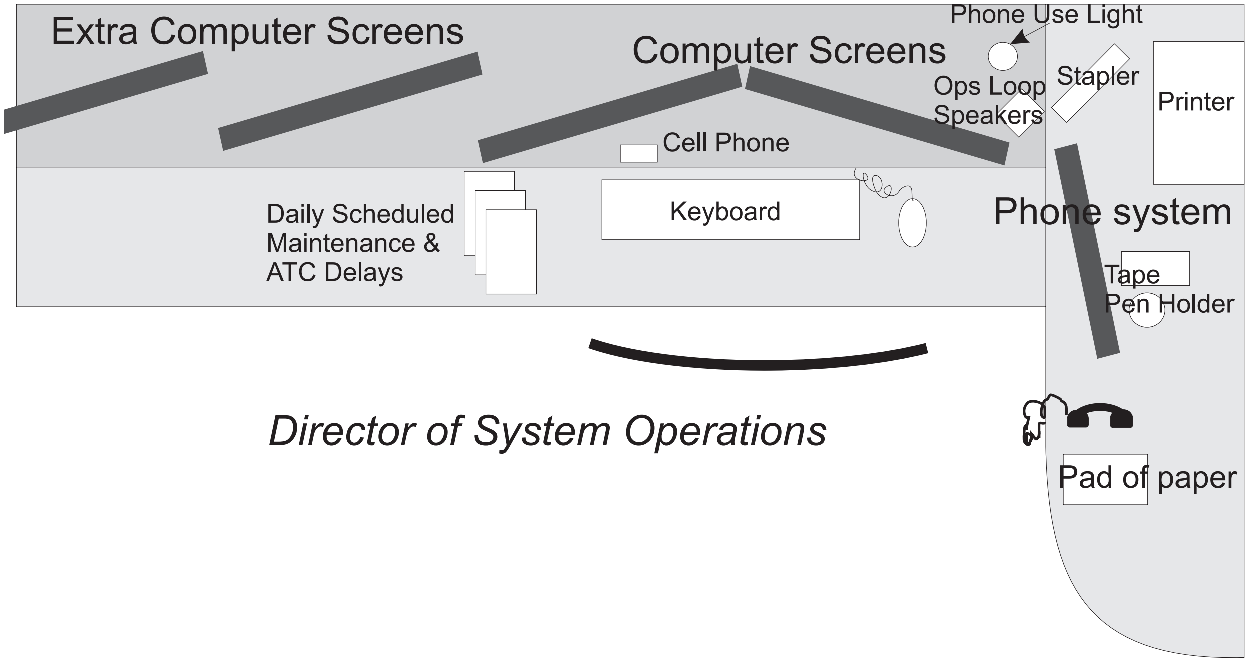


Figure 3. Physical Model of DSO's Desk

i.e., which aircraft were due for maintenance somewhere, and ATC issues as passed through by the Chief Dispatcher via a series of sheets of paper. The sheet with the day's critical maintenance is important because it is the easiest way for the DSO to remind himself which airplanes were not good options to swap, as this was not possible to determine easily from the VisOps software tool.

As the primary focus of all SOC personnel are their computer screens, it is important to understand how they use these tools. The vast majority of information gathering, organization and dissemination happen via the software tools on SOC's computers. The physical model shown in Figure 4 is a recreation of the layout of an actual computer setup by one of the DSOs interviewed. This layout, with one screen being solely dedicated to the VisOps tool, was common among the operations control group. However, even a whole 19" monitor is not large enough to display the entire fleet at a sufficient resolution so that it can be read clearly. The right side of the monitor illustrates the size of the image when half of the fleet is visible and the left side of the monitor illustrates the number of aircraft that can fit when enlarged enough to read. The other monitor is then free for all of the other tools. The DSO had chosen to organize this monitor by placing the Out of Service Aircraft Tool in the upper right hand corner to help him monitor the aircraft that were out of service due to unscheduled maintenance. As there were a large number of aircraft (6-9%) out with unscheduled maintenance during the observation period, this made good sense. The DSO placed two SABER terminals along the bottom of the screen so that he could pull up information on specific aircraft or flights. In addition, the DSO had placed his shift log in the upper left hand corner to serve as a reminder to maintain a good record of the shift's events[2].

[2]The log tool shown in this model is only representative of the size and shape of the log tool used, as the image of that tool was not recording during the inquiry

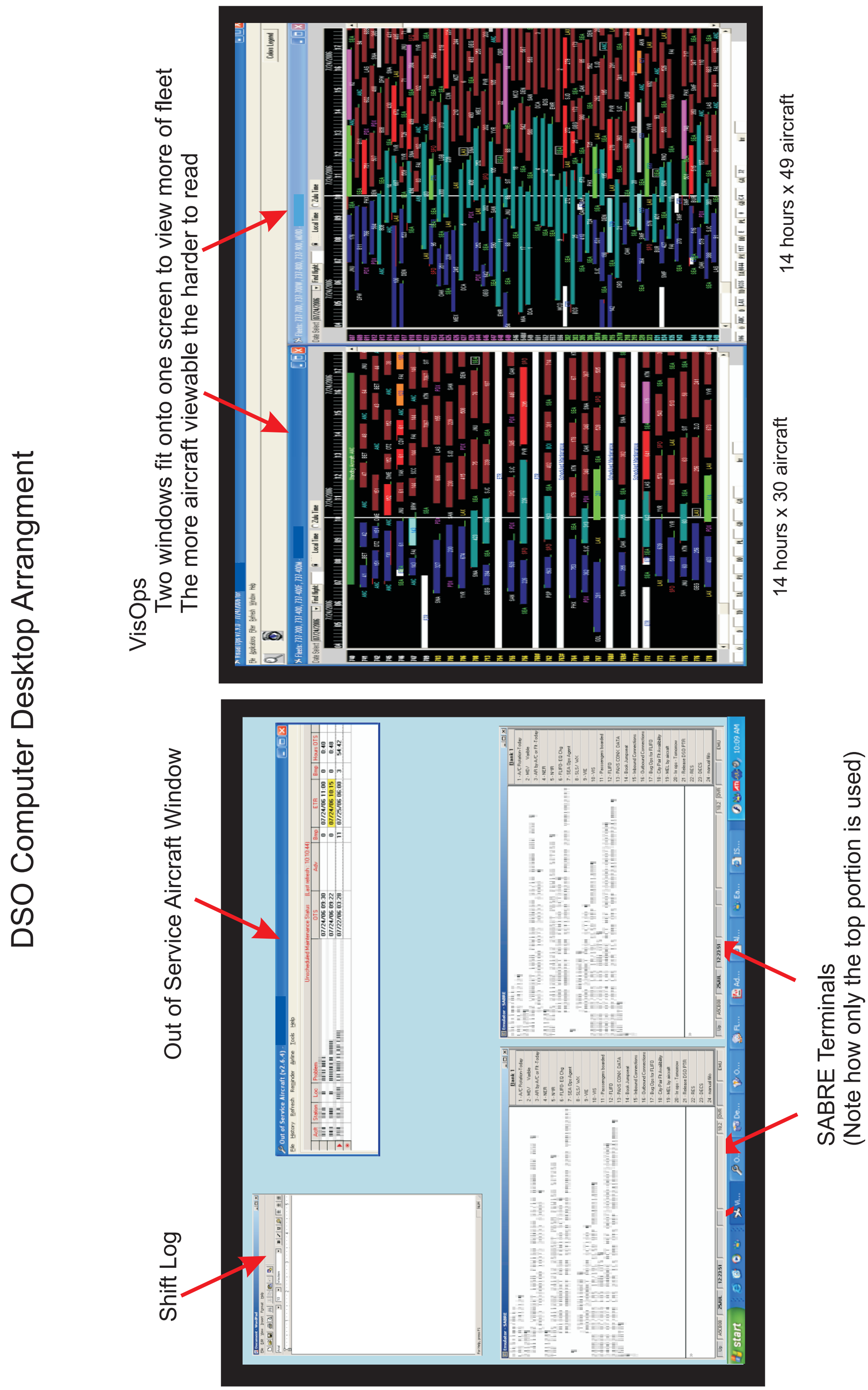


Figure 4. Computer Screen Artifact Model

4 Artifact Models

The purpose of the artifact model is to determine how artifacts help or hinder work. The SOC personnel use a variety of artifacts to help them with their work; however, few of them are physically tangible. Consequently most of the following artifact models will be software tools.

4.1 Visual Ops

The DSO, MCO and LMP get the majority of their information about the state of the airline and its schedule adherence through the Visual Ops tool, commonly called VisOps. A screen capture of VisOps can be seen in Figure 5. VisOps is a Gantt-chart presentation of the airline's schedule organized by aircraft tail number and time. VisOps represents each scheduled flight as a horizontal rectangle, which are arranged in a row corresponding to their assigned aircraft. The flight number and origin and destination are available in small text on the display. By selecting a specific flight, more information appears at the bottom of the screen in small designated boxes.

One common task is to locate a specific flight in VisOps, often with the aim of determining its aircraft. Unfortunately, the Find Flight feature at the top of VisOps does not function properly, leading users to find an alternative method (often they just scan the schedule until they find it) for locating the flight. This wastes valuable time and was clearly not the intent of the VisOps designers. Additional tasks that VisOps does not support include finding possible aircraft to swap between flights. This requires finding a set of aircraft with flights passing through the same station for a given time window. Presently this is done manually with the aid of the cross-hair tool. Additionally, since DSOs often preemptively plan for future occurrences a feature to allow possible future schedule changes should be included. Presently the users either print out the plan, write it down, or minimize the screen for future printing.

4.2 Out of Service Aircraft Tool

The Out of Service Aircraft tool, shown in Figure 6, provides a list of all of the aircraft currently out of service either for unscheduled maintenance (upper block) or scheduled maintenance (lower block). As the primary concern among the operations control group is with the aircraft out due to unscheduled maintenance, most of the time this tool is sized to only show the upper block. Additionally, as the tool provides more information than usually needed, it not usually opened to its full width. The most pertinent information to the operations control group is the estimated time ready (ETR), because even if a plane is returned from maintenance early it is not useful to the schedule recovery plan unless the DSO is able to incorporate it back into the schedule. The column preceding the ETR is la-

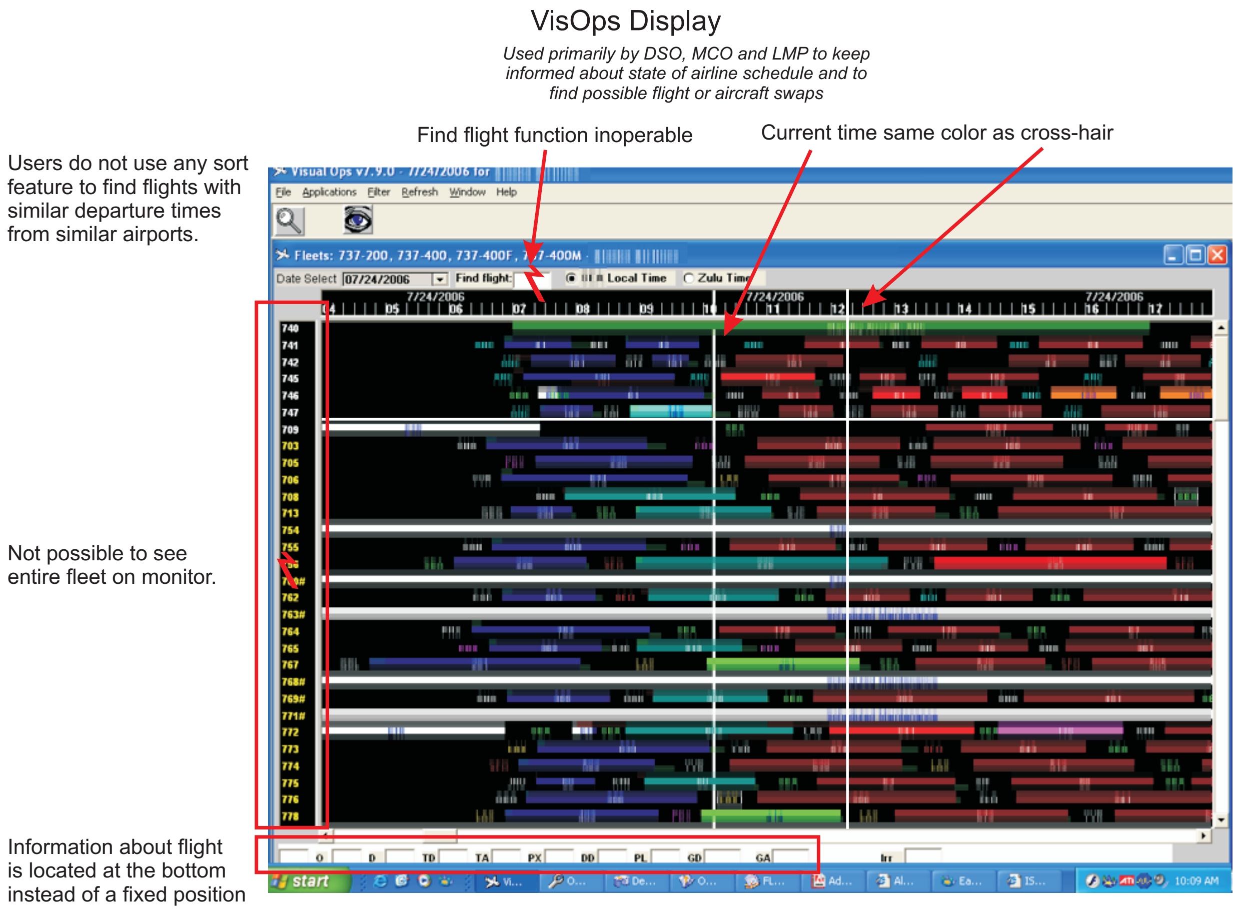


Figure 5. Computer Screen Artifact Model

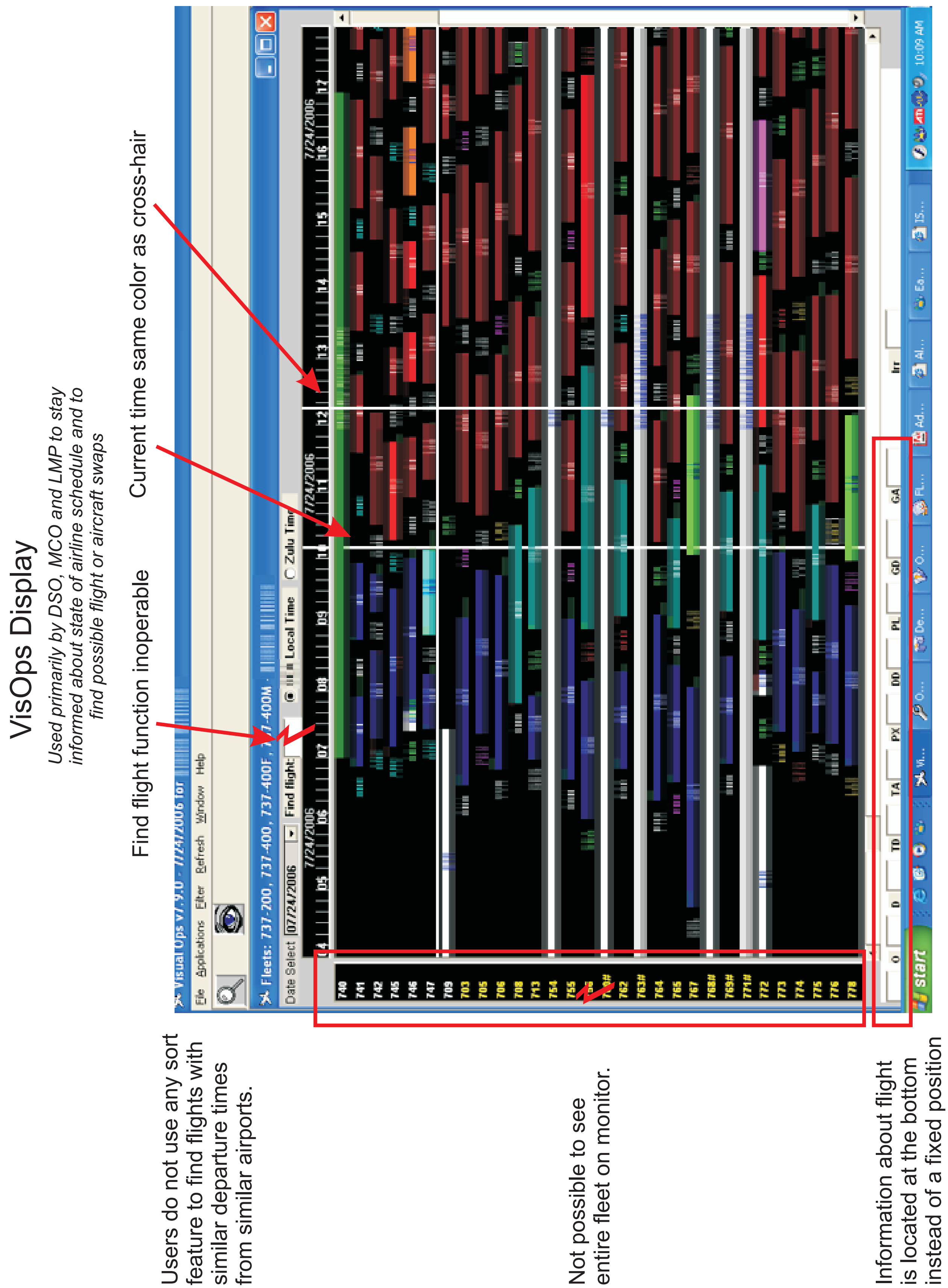


Figure 6. Out of Service Aircraft Tool Artifact Model

beled “Adv” (Advise) and, if a time is placed in this block, it indicates that it is not possible to estimate a ready time, so instead they post a time at which they will communicate with the SOC to provide a status update on an aircraft. The information displayed by the Out of Service Aircraft tool is maintained by the Maintenance Controllers and consequently may be out of sync with current conditions by as much as twenty minutes on a busy day. Thus some DSOs prefer to monitor the maintenance radio frequencies to keep informed. The only thing lacking on the tool is an indication of how “good” the ETR is. Consequently there are many phone calls between the DSO and either the MOM or the MCs on this topic.

The Out of Service Aircraft tool also includes the ability to create modal dialogs (i.e.Pop-up messages) to users. These messages are essentially alerts as they appear on top of all open windows and block the execution of any action until they have been closed. Figure 7 contains the artifact model for the modal dialog. Although there are two lines of text the first line is not useful because the codes used to indicate the sender are too obscure, and because the time the alert is sent is irrelevant since the presence of the alert renders the computer unusable until it is dismissed. The second line contains the useful information, i.e., the aircraft of interest and a brief description of the problem or resolution. As the modal dialog must be ‘removed’ to unlock the computer often the messages go unread because the user was involved with another task at the moment. It would have been nice to have the messages cataloged somewhere in the Out of Service Aircraft tool, and perhaps reflected by messages next to the aircraft listing when appropriate.

4.3 Sabre Terminal

The Sabre Terminal provides a text-based, command-line terminal to access the Sabre database. The DSO, LMP and CMO all use this interface to access information about specific flights, aircraft and customers. It is quite frequently used to determine how many passengers have boarded an aircraft as a measure of actual departure time. The tool has two separate command lines and a column of buttons for frequently used commands or tasks. The buttons are used sparingly either because of the users expertise with the text commands or because the task was not represented by a button. Similarly, the secondary command line is not often used (never during this interview) as often it was simpler to switch to another terminal all together. The only complaint users had with the terminal was that it would regularly time out after a relatively short period of inactivity – often at an inconvenient time. Twice I witnessed the terminal time out during a very busy period. This was the only time I witnessed anyone in the SOC lose their composure.

4.4 GateSheet Tool

The GateSheet tool is of the same design as the VisOps tool, and the artifact model of it is shown in Figure 9. It too contains a Gantt-chart representation of the airline hub’s gate schedule organized by gate number and time. The rectangular entries represent aircraft

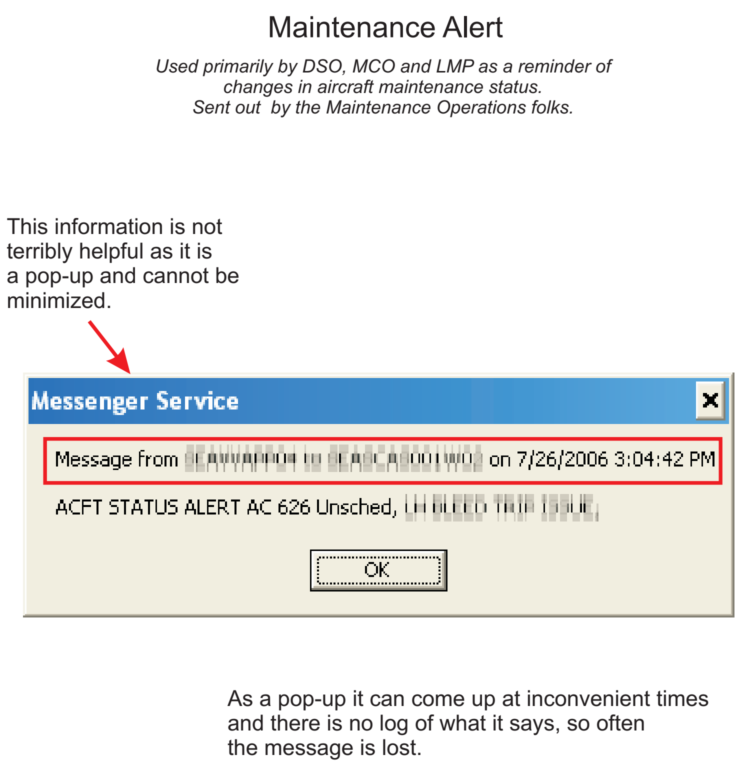


Figure 7. Maintenance Modal Dialog Artifact Model

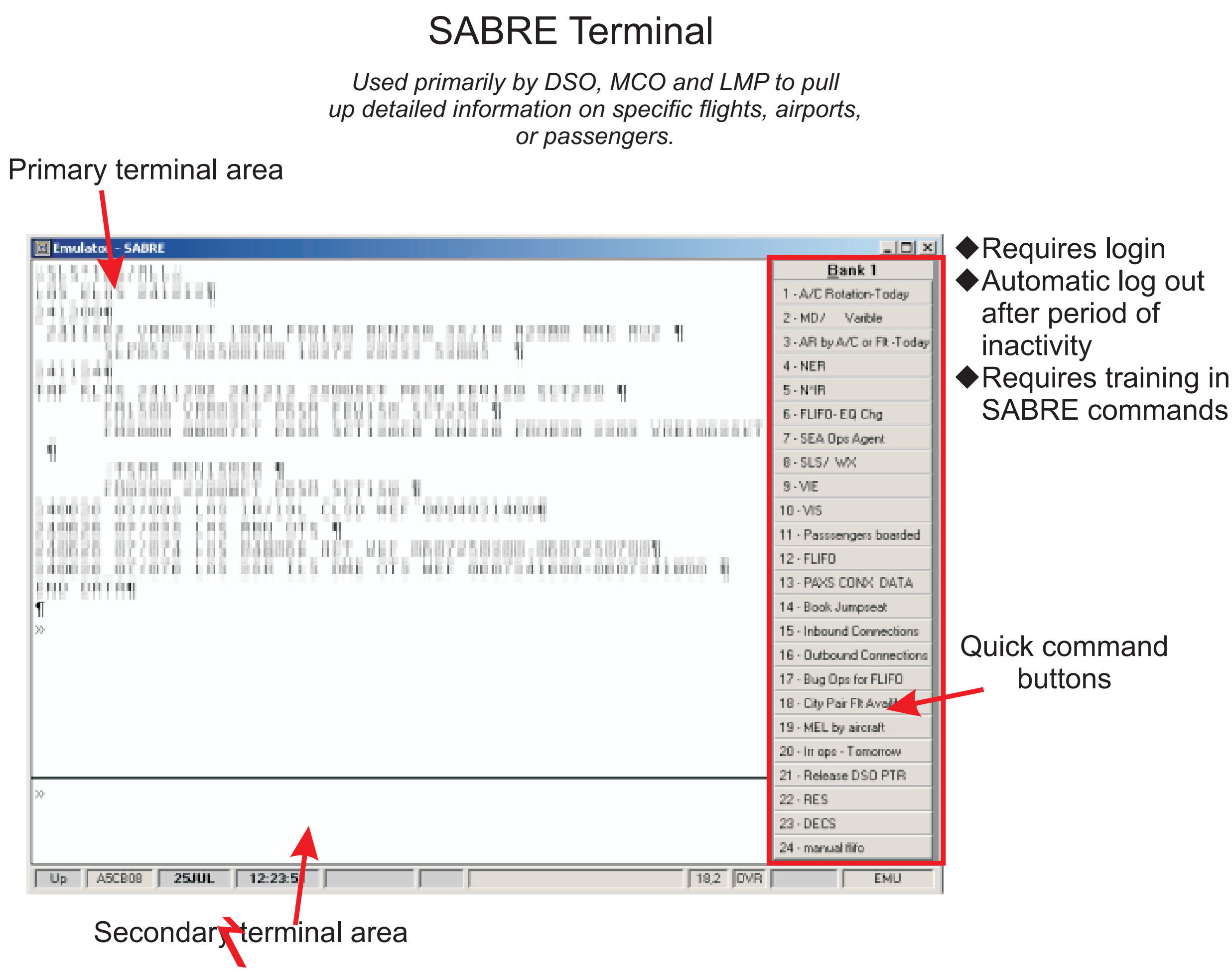


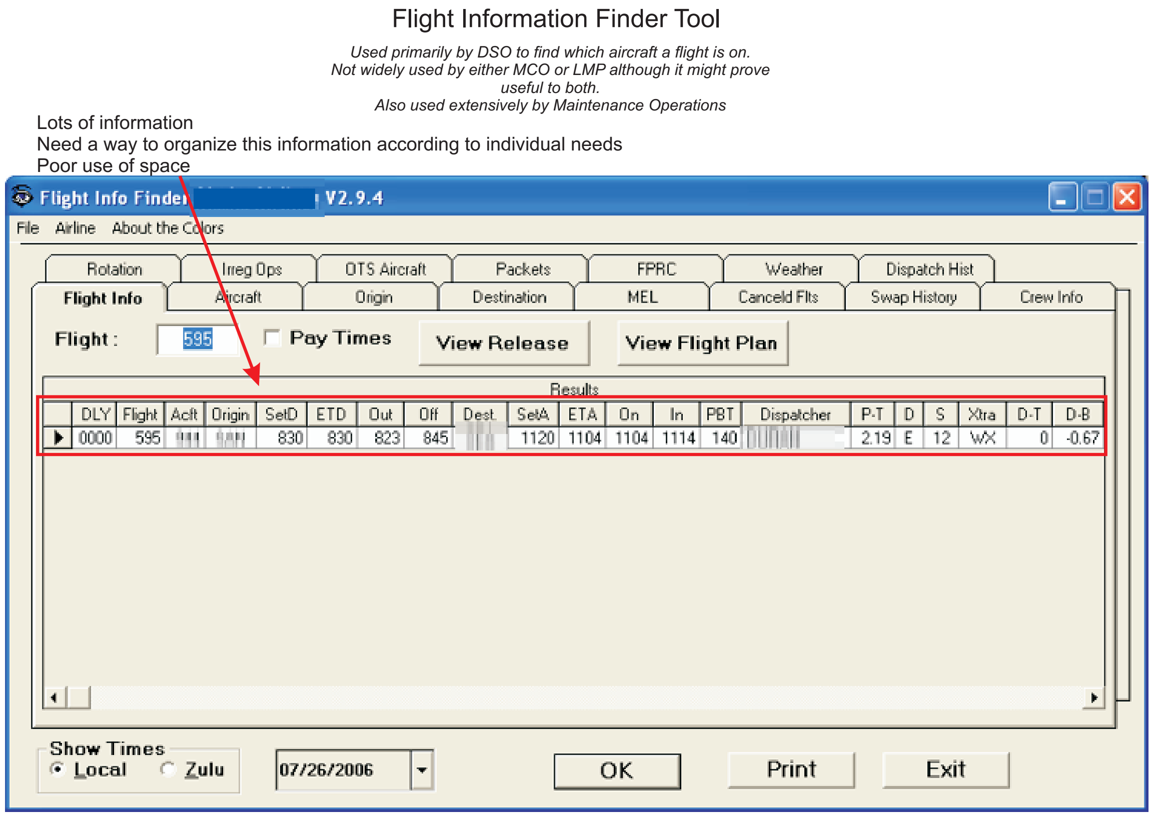
Figure 8. Sabre Terminal Artifact Model

occupation of the gate slot. It suffers from similar issues to the VisOps tool in that the user must decide between seeing the entire schedule at once and actually reading the text. It is primarily used by the DSO to detect any aircraft who have declared a maintenance issue via ACARS and may consequently not be ready to take their next flight on time. The existence of a maintenance issue reported via ACARS is indicated by the addition of parentheses around the flight number.

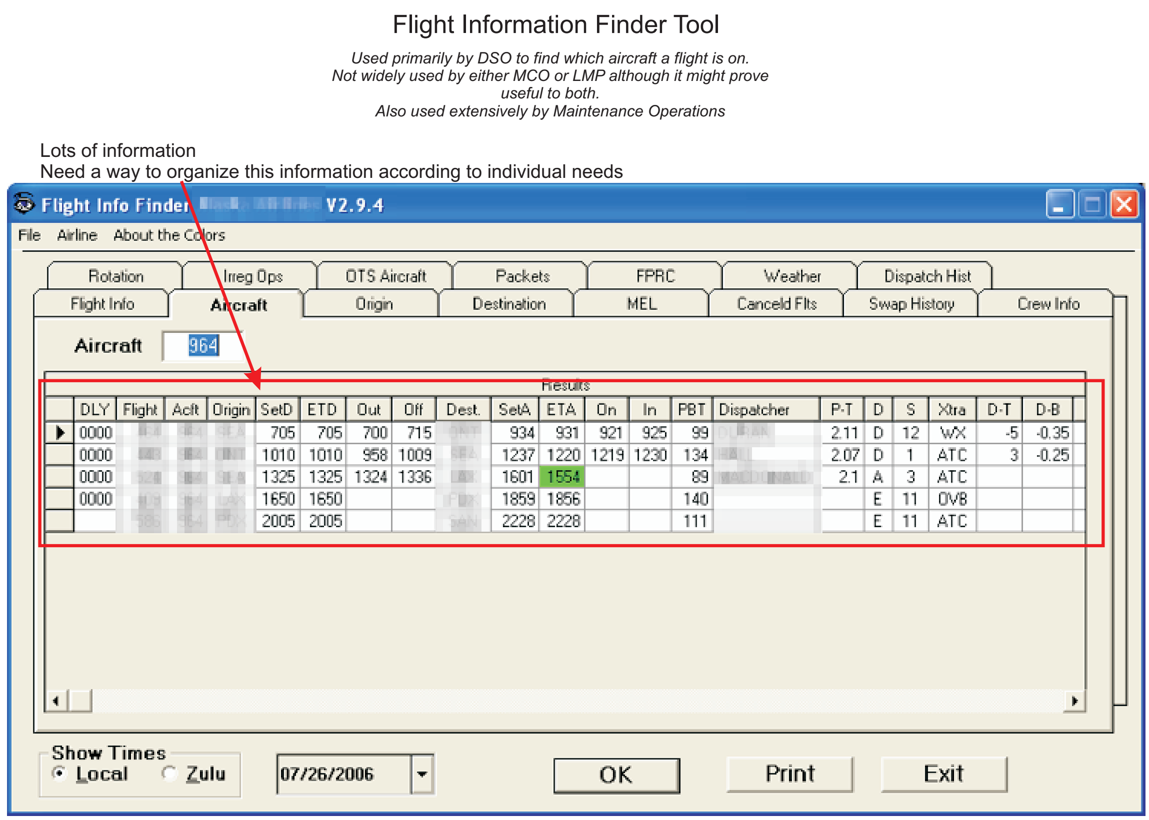
4.5 Flight Information Finder (FIFO)

The Flight Information Finder, known by the SOC personnel as FIFO, is a powerful tool which uses spreadsheets to allow users to search for and sort information quickly. Figure 10 shows two of the fifteen tabs. These were the only two tabs that were observed being used during the interview. In general, the FIFO was not frequently used – despite its apparent usefulness. However, upon closer inspection, it is apparent why SOC personnel prefer to gather information from elsewhere – information overload. For example, the Flight Information tab contains all known information about individual flights. There are over 21 fields viewable on this screen-shot alone. As it does not appear that different fields can be hidden or removed, it is probably difficult to find necessary information quickly. Similarly, the Aircraft Tab allows its user to view all information pertaining to the flight schedule for a specific aircraft. As the number of columns is identical to the aircraft page it generates an analogous information overload.

Figure 9. Sabre Terminal Artifact Model



(a) Flight Information Tab



(b) Aircraft Tab

Figure 10. Flight Information Finder Artifact Model

5 Information Flow Model

The purpose of an information flow model is to show the flow of information between individuals and artifacts within the system and to note any breakdowns in information flow. The flow model for the SOC personnel involved both individuals and computer systems. Individuals are represented by ovals. Artifacts (tangible pieces of information) are represented by small rectangular boxes, and areas of information storage are represented by shaded boxes. The flow of information between these elements is illustrated by arrows. The size of the arrows indicates the amount of information flow, thicker indicating more. Breakdowns in information flow are represented by lightning bolts superimposed on the flow.

Figure 11 contains the information flow model for the entire SOC in general with a focus on capturing all of the individuals actively involved with "day-of" operations. Figure 12 specifically focused on the DSO.

At the center of the information flow is the DSO because the majority of information flows through the DSO position. The DSO is surrounded by the other members of the SOC, the LMP, MCO, Pilot and Crew Schedulers, and Dispatchers. As can be seen from the model the DSO primarily corresponds with the LMP and the MCO. In addition during the period of this inquiry the DSO also corresponded regularly with the maintenance personnel, equally between the MOM and the MCs. As everyone was connected via the computer systems, the phone system, and the email system, these have been indicated as a gray oval surrounding the information flow model. Other areas of heavy communication include the pilot and crew schedulers, as they sit directly across from each other and use similar tools. The MCO and the stations are often in close communication as the stations pass information about weather and other potential problems to the SOC and receive information regarding schedule changes in return. The maintenance personnel are also in close communication as the MCs and the MOMs are constantly discussing problems and phoning the line maintenance facilities. Unfortunately, this communication is often one way, with the line maintenance only calling in to report problems and to request MELs; line maintenance rarely calls in with the maintenance updates, which SOC decisions may hinge on.

Three other problems are identified in Figure 11. They include multiple computer databases which do not share information well with each other, a VisOps program which does not allow possible schedule changes to be saved and transferred between individuals, and a delay request sheet maintained by the MCO on paper. The first problem results from multiple databases storing different sets of data and requiring specific tools to be used to access the data. Specific problems arose between the maintenance databases and the flight information database leading to multiple entries of the same information in separate databases and some information sources being more up to date than others. The second problem is with VisOps, discussed previously in Section 4.1; consequently the DSO must print out the proposed plan and hand it to the LMP to check and implement. The third problem is the procedure for the MCO to take delay requests from the stations, involves writing the request on a piece of paper, which must then be transcribed later into electronic form to investigate and analyze.

The second information flow model focuses specifically on the DSO. In this model, instead of focusing on the quantity of communications, it distinguishes between the different types of communication: personal, phone and electronic. You can tell from the different line types that there is a lot of face-to-face communication in the SOC. This is primarily because of the proximity. It also has to do with the DSO being mobile – often getting up and walking over to ask questions or explain a plan. It is clearer from this model that the DSO uses a specific subset of computer tools including VisOps, FIFO, Sabre Terminal and the Out of Service Aircraft log. While a majority of the problems are the same, this model highlights an additional problem of the handoff between shifts. Presently it is done verbally which is good for a quick turn over, but which does not leave a good trail paper trail for the following shift. The DSO does keep a log, but it was not clear whether other shifts had access to the logs or not. Additionally as the different SOC members use different tools, the only way to send information electronically is to use the email system, which requires much retyping of information.

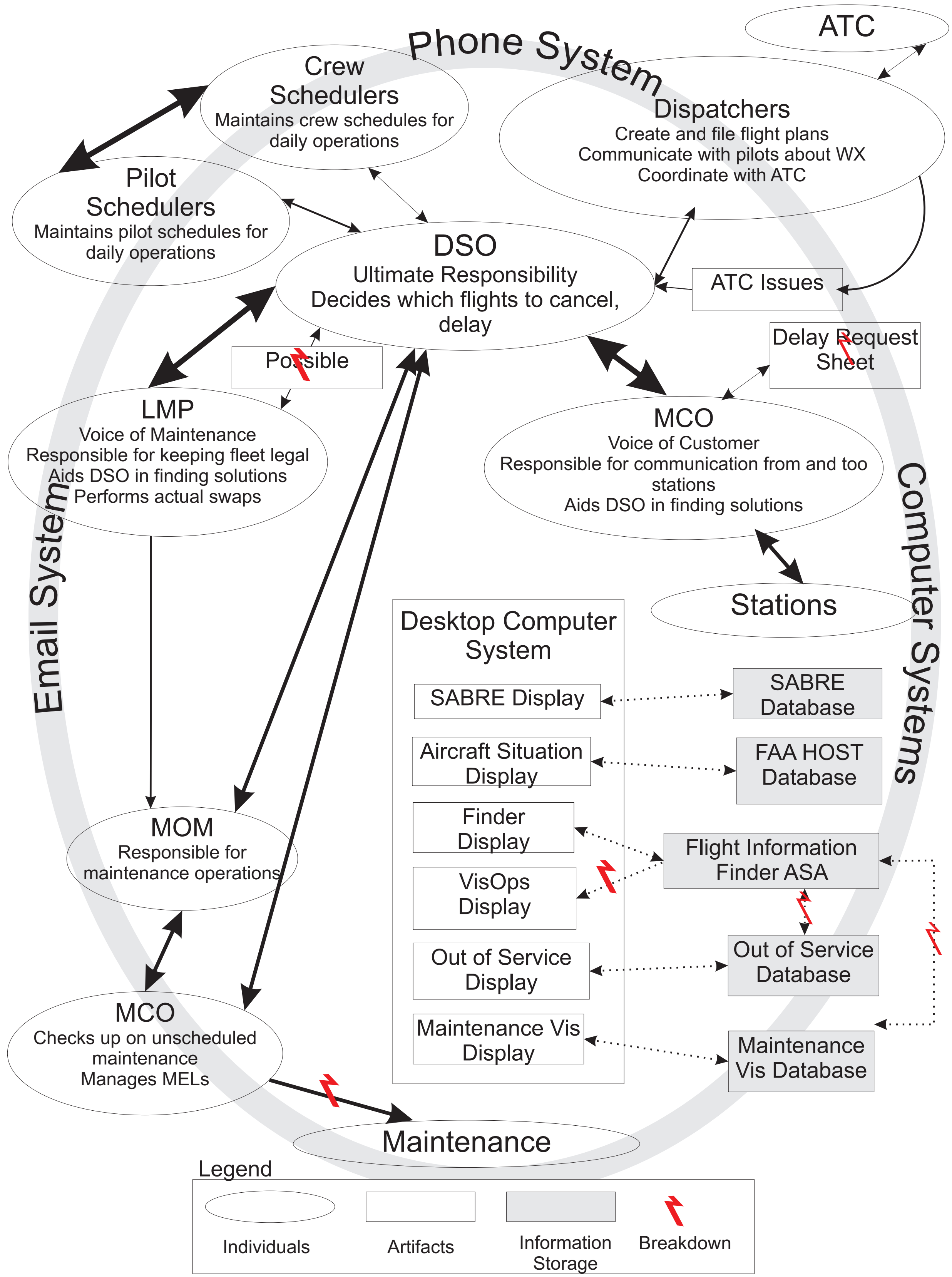


Figure 11. Information Flow Model

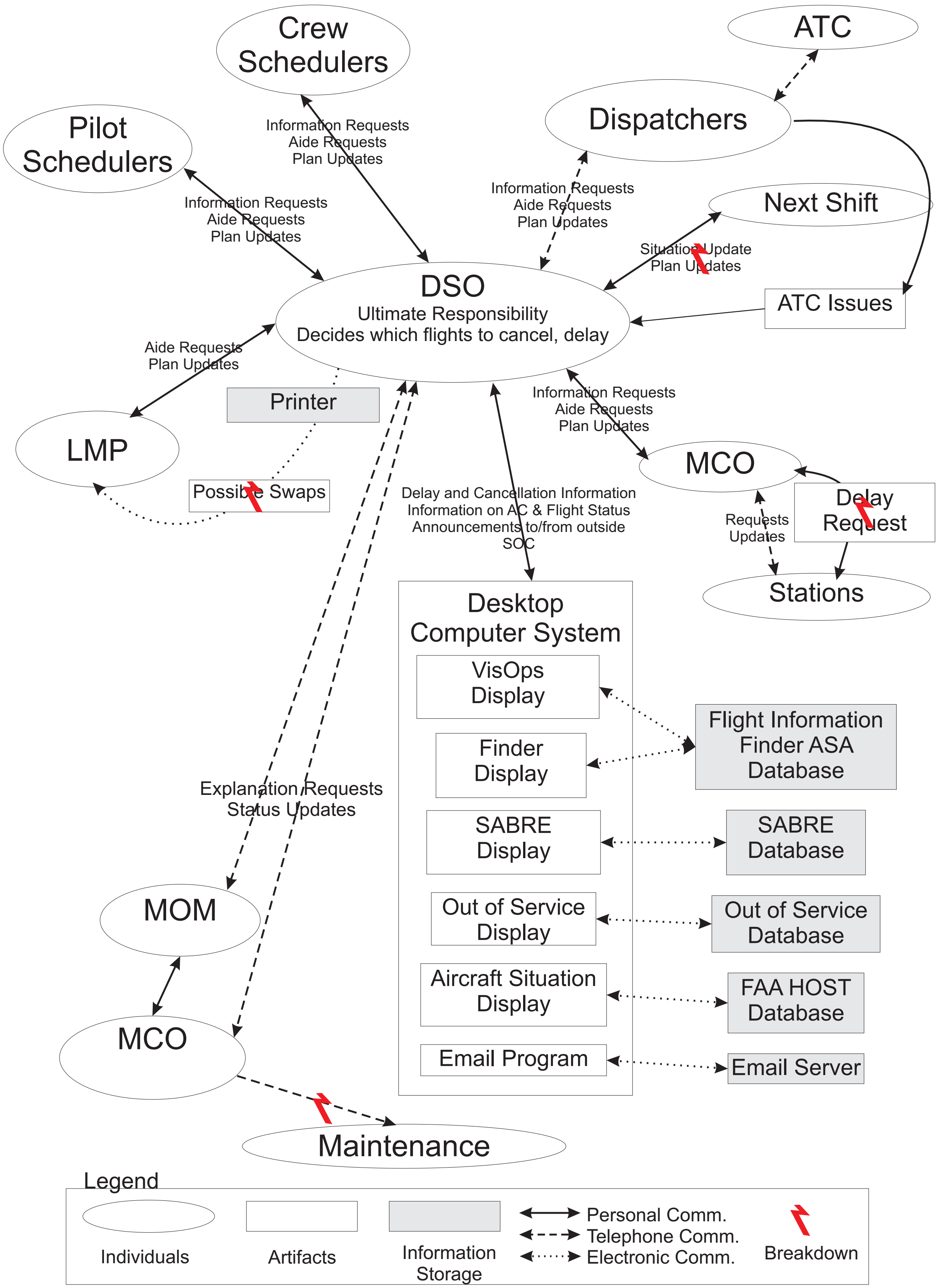


Figure 12. Information Flow Model – DSO Focus

6 Cultural Model

The purpose of a cultural model is to understand the cultural forces which impact both the work environment and the work itself. In a cultural model the main influencers on a position are represented, such as people, policies, values, preferences, or points of pride. In addition, the specific topic of influence and direction of that influence are shown.

The cultural model for the airline is shown in Figure 13. The DSO is shown at the center of the model, as he functions as the center of the SOC. The DSO is surrounded by, first, the other members of the operations control group, the LMP and the MCO. They represent the two primary interest groups to please — the customers and the maintenance schedule. While there is generally very little acknowledged trade off between the two, they cannot always be simultaneously satisfied. The DSO is also surrounded and supported by the crew and pilot schedulers and the dispatchers. The DSO generally relies on the schedulers to come up with staff to pilot and crew the flights — often asking them to find people where none exist. Lack of extra pilots and crew often causes tension because while the schedulers understand that their job is to find plots and crew to schedule, it is often just not possible.

The relationship between the DSO and the dispatcher is a little strained at present because the DSO believes that it is the dispatcher's job to closely monitor their aircraft for deviations from the schedule and to notify the DSO upon detection of such deviations. Often, however, the DSO spots the deviations herself and must then look up the dispatcher in charge of the flight and call the dispatcher to ask what is going on with the flight. On the other hand, the dispatchers feel that they do a good job making sure the DSO does not forget about all of the restrictions for the different destinations as they make adjustments to the schedule.

Underpinning everything is management who are seen as generally supportive in general but not terribly helpful, as there is often nothing specific that they can do to help with an ongoing situation. Sometimes, however differences of opinion do occur. For example, recently in order to find enough pilots to cover a number of scheduled flights, the schedulers used management pilots. The alternative would have been flight cancelation. A memo from upper management made it clear that this was not an acceptable solution and would not be tolerated in the future. The schedulers and DSO felt frustrated.

Also influencing the DSO are the maintenance personnel. The maintenance personnel inside the SOC and the DSO are generally have the same goals although the DSO often feels left out. Even though the DSO has as much information as the maintenance personnel, he often believes that maintenance has more (or ought to have more). This is not because the maintenance personnel are purposefully not updating the DSO, but because the maintenance personnel inside the SOC are often isolated and devoid of solid information and frustrated with the maintenance staff outside the SOC because of lack of information from the line maintenance staff. Comments such as "what have they been doing for the past 12 hours?" were commonly uttered by the SOC maintenance personnel. It was not possible to tell from the inquiry if a similar resentment was felt from the line maintenance staff.

On the other side of the cultural model is the airline's station personnel. The MCO appears to keep their needs at the forefront of discussion and the DSO appears to keep them informed via the MCO, often delaying action until they have been informed. Their desires are generally inline with the DSO's, not to cancel flights and take a small scheduled delay rather than suffer an unscheduled one anyway. When the news is not good, however, the MCO is generally the one to let the external stations know first, providing a crucial head-start to get themselves organized to deal with frustrated customers. The customers are primarily handled directly by the external station staff.

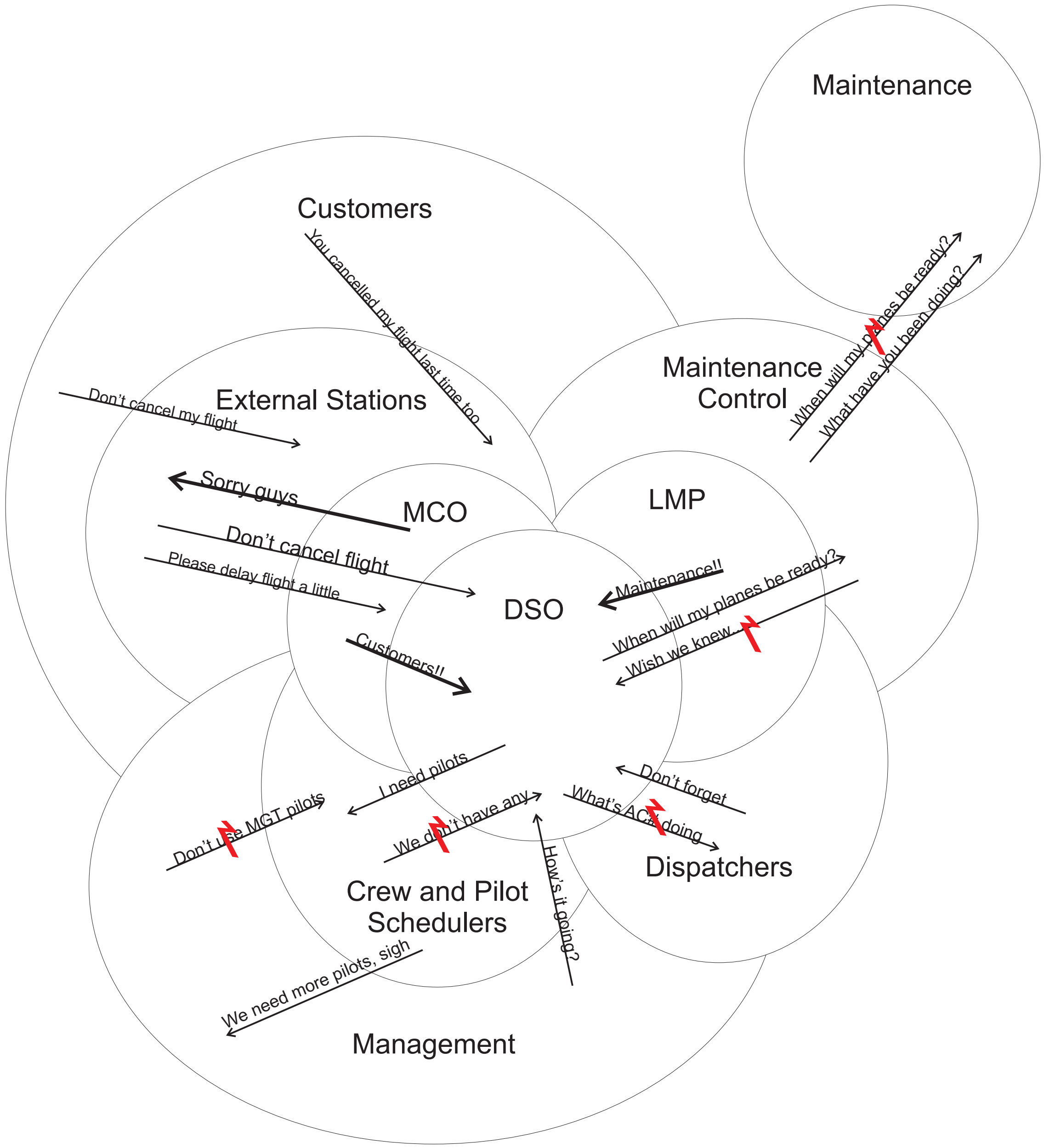


Figure 13. Cultural Model

Maintenance not completed on time	DSO
Trigger:	Maintenance Pop-up alerted that ready time for AC slipped
Intent: Double check that AC was not going to make ready time	Called maintenance controller AC was indeed going to miss ready time
Intent: Needed to find new AC to cover flight	Turned to VisOps to attempt to find another plane to take flight Found something promising Checks list of nightly maintenance
Intent: to use the filter function to manipulate these AC to see if he could find a swap that worked	Wrote down all tail numbers on a pad of paper Used VisOps filter by AC to isolate planes Played with flights until found a working solution
Intent: to give solution to LMP for checking and implementation	Printed solution Handed solution to LMP
Intent: to make sure MCO and stations informed	Informed MCO of swap, and asked her to work with LMP MCO confirmed the swap with LMP and called station to inform them of change LMP made swap

Figure 14. Sequence Model: Incomplete Maintenance

7 Sequence Models

The purpose of the sequence model is to examine procedures used by individuals to complete their work and to examine the motivations behind the actions taken, similar to many forms of task analysis. As the work of the SOC personnel is more goal-driven than procedure-driven, sequence models provide limited utility in understanding the pattern of work done by the SOC personnel. However, sequence models can help begin to explain the tasks and the motivations and intentions behind their actions.

The first two sequence models shown in Figures 14 and 15 show the importance of correctly predicting the ready time for an aircraft taken out of service by unscheduled maintenance. In both cases the ready time slipped passed its estimated/secheduled time and impacted the airline schedule. In the first case, Figure 14, the initial trigger was a maintenance pop-up alert. This was followed by a routine aircraft swap to minimize the effects of the delayed return to service. While the entire issue of needing an aircraft was not resolved at this point, the immediate issue of attempting to maintain the published schedule was. In the second case, Figure 15, the initial trigger was a vigilant DSO who noticed the slip on the VisOps tool where aircraft out for maintenance are represented by white rectangles. As with the first example a solution to the immediate problem of schedule adherence was identified, but unlike the first example, the problem was identified hours before any specific action needed to be taken. The approximate times are listed to provide added insight into the timing of the events. It is interesting to note that this problem spanned two shifts,

Maintenance causes delay	DSO
Trigger:	(1330) Checking VisOps and spots flights scheduled for AC coming off of maintenance
Intent: Curious about probability of making ready time. If not it plans can be made now.	(1330) Called maintenance controller AC was indeed going to miss ready time of 1630 AC should be ready by 2100, will call and update
Intent: Wanted to make contingency plan	(1334)Turned to VisOps to attempt to find another plane to take flight Found something promising
Intent: to use the filter function to manipulate these AC to see if he could find a swap that worked	Wrote down all tail numbers on a pad of paper Used VisOps filter by AC to isolate planes Played with flights until found a working solution
Intent: to save for next shift, and because it is not possible to save	Minimized solution for later
	(1353)Maintenance returns call AC should be ready by 2200 not 2100
	SHIFT CHANGE
Intent: Wanted to find out specifics about AC that his predecessor had mentioned	(1416)Called maintenance New advise time 1730 Rechecked original plan Plan no good for 2200 ready time – will have to delay
Intent: To check up on AC ready time	(1730)Called maintenance Ready time 1000
Intent: to make sure MCO and stations informed	(1732)Advised MCO of plan to delay

Figure 15. Sequence Model: Maintenance Delay

Possible bad weather problem for unaccompanied minors (UM)	MCO
Trigger:	Diversion last night due to weather and pilot contract time out lead to several UM being put up in hotels. Bad weather forecast again for tonight.
Intent: Explain situation and suggest cancelling Ums	(1420)Called station manager No answer
Intent: Needed to find out how many Ums were scheduled	(1421)Used SABRE terminal to look up UM load Only one UM scheduled
Intent: Explain situation and suggest cancelling Ums	(1436)Called station manager again Advised no Ums or young teens tonight
Intent: Explain situation and suggest cancelling Ums	(1533)Called UM center

Figure 16. Sequence Model: Weather Precautions

and that some duplication of effort was therefore necessary for the second shift DSO to acquaint himself with the situation. In fact the sequence lasted so long that the contextual inquiry did not capture the final resolution of the issue after the plan was presented to the MCO.

The third sequence model shows the breadth of issues that the SOC personnel are required to handle. In this sequence model, shown in Figure 16, the CMO requests that no unaccompanied minors (UMs) or young teenagers be boarded onto certain flights because of possible diversions caused by convective weather, as had happened the previous evening resulting in several stranded UMs. The presence of UMs required the cabin crew to essentially baby-sit overnight as they had been diverted to an airport not serviced by the airline. Again, in this sequence model we can see how the work on this specific issue was spread out over time, and interrupted by other issues.

Whereas Figures 15 and 16 show how some issues can take a long time to fully resolve themselves, as the DSO waits until all information is available before committing to a decision, the final sequence model as shown in Figure 17 demonstrates that some problems are of a large enough magnitude that they take up almost all of the DSO's time and energy over a short but significant period. Figure 17 shows the activities of the DSO, CMO and Pilot Scheduler in response to a bird strike. The bird-strike occurred shortly after takeoff and the plane returned safely to its origin. As the sequence model shows there was an hour of intense activity which occupied all of the DSO's time and a significant portion of both the CMO and the Pilot Scheduler. Most of the activity centered around trying to figure out 1) the extent of the damage 2) an estimate of the ready time and 3) a set of contingency plans to minimize irregular operations and the resultant passenger disruptions.

Bird-strike Cases Delay

DSO, MCO, Pilot Scheduler

Trigger: Bird-strike on AC 888 – probably damaged radome

Intent: Work out what to do as soon as possible if we have to cancel flight

(0818)MCO – called out solution
DSO – wrote solution down on piece of paper
DSO – walked over to explain plan to Pilot and Crew Scheduling
MCO & DSO continue discussion about other alternatives while Pilot and Crew Scheduling work on finding new crews

Intent: Wanted to verify damage enough to cancel

(0824) DSO calls maintenance
Verified big damage
MCO – looks up impact on SABRE and calls station

(0825) Maintenance called
Possibility of ferrying AC with radome damage
MCO – asked to wait 5 minutes to cancel next flight

Intent: to try not to cancel follow on flights or current flight

(0826) MCO – calls sister company and finds they have an RJ on standby
DSO – types into log
MCO & DSO – discuss implications plan for AC to be out for 24hrs

Intent: to come up with a contingency plan

(0831) DSO – asks Pilot Scheduler to find crew to ferry AC home later in the day
DSO – checked VisOps for flights to cancel
DSO – cancelled three follow on flights
MCO – called stations
DSO – interrupted by maintenance slip on another AC

(0836)Maintenance calls
Found radome, thinking of maintenance ferry
Ready in 3 hours after arriving

Intent: Wanted everyone to be informed

(0840)DSO – told MCO & Pilot Scheduler about possible ferry
MCO – briefed DSO about PAX situation from bird-strike

Intent: To inform rest of airline

(0842)DSO – put in an ETD on the Flight Information System

Intent: Trying to figure out what the situation will be tomorrow with pilots as this will probably drag on until then

(0845)DSO – wrote up issue in log
DSO – went to ask about tomorrow's crew situation

(0851)MCO – briefed DSO that sister company was not going to loan spare

Intent: Curious why the plane returned to the gate – not a good sign

(0856)DSO noticed block turn on Flight 333 due to door issue
Looked up agent to call on SABRE
Called agent

(0859)Updated log
DSO – dealt with some other issues

(0903)Maintenane called DSO
Not able to ferry – too much damage
No shipping information yet on how long
DSO – delayed some flights affected
DSO – consulting VisOps for anything else to be done

Intent: Trying to find some way to keep from cancelling so many flights

(0911)Maintenance updated ready time on another AC
(Can use it to cover some flights)

(0912)Call from station
AC with Flight 333 does not look good

Intent: To take some load off of the DSO and to cover Flight 333

(0913)LMP handles swap to cover Flight 333

(0915)Maintenance calls about Flight 333 damage
Door damage out of spec – it goes out of service
DSO – checks load on SABRE, uses VisOps to find options
DSO asks MCO about options

Intent: Trying to find some way to keep from cancelling flight that follow Flight 333

(0918) MCO advises on which is best to cancel
DSO – asks LMP to make swap
DSO – updates log
DSO – sends flash message

(0923) Maintenance calls
AC 888 has a new ready time of 1900-2000

Figure 17. Sequence Model: Bird Strike

8 Design Implications

The major issues identified during this inquiry can be grouped into four groups:

- Lack of reserve planes, pilots and crews
- Apparent ineffectiveness of line maintenance staff
- Software tool limitations
- Lack of constructive feedback and analysis of SOC effectiveness

The first two of which are beyond the purview of the SOC or the personnel within the SOC. I mention them here because I believe that they are issues which the airline will need to address if it is to significantly improve its operations and its ability to recover from irregular operations. The second two are more interesting from the standpoint of work redesign and software tool design. They will both be discussed in turn.

8.1 Software Tool Limitations

The first thing that should be done to address the software tool limitations is to integrate as far as possible the multiple databases so that all common data is kept in a single location and, no matter which tool is used to update the information, all tools will register the change at the same time.

The second thing that should be done is to make improvements to the VisOps tool. First, fix the flight-find feature, which will eliminate the hunt-and-peck solution of flight finding. Second, change the color of the line indicating the current time from white to yellow to make it easier to distinguish from the cross-hair tool. Third, a geographical search/sort feature should be enabled to allow users to quickly find flights with specified destination during a specific time window. Fourth, aircraft which are scheduled for maintenance that evening should be indicated on VisOps. Further, aircraft currently operating under minimum equipment lists (MELs) should also be clearly flagged in VisOps.

A thorough work-redesign would integrate VisOps into a more comprehensive support system which would track problems from their identification, through data collection to solution identification, consultation, solution checking and solution execution. At present there are multiple disparate tools which facilitate problem identification, data collection and solution execution. VisOps is the only tool which enables, but does not really support, solution identification. Presently, there is no software tool which supports either consultation or solution checking.

8.2 Feedback

Presently the SOC personnel operate without any consistent, quantitative feedback regarding the relative merits of their decisions on overall system performance. Lack of feedback about the impact that their decision had on system performance means that SOC personnel are unable to measure in any quantifiable way their performance on specific problems or even the performance of the entire SOC for a given shift and apply this knowledge in the future. Further, personnel outside of the SOC may often be left wondering what is going on at the SOC – as they are not easily able to understand all of the competing interests that must be balanced. In order to provide this type of feedback more data needs to be collected and analyzed, e.g. the causes of delay and cancelations. At present it appears that while much data is being collected it does not appear to be analyzed or reported back to the SOC personnel. This analysis is important because it is difficult to see the effects of investment in the SOC or other areas of the airline without it.

9 Summary

In summary the SOC at works well during periods of low disruption and is amazingly capable of maintaining the schedule even with 8% of their aircraft unavailable due to unscheduled maintenance. Some of the more major operational challenges that I witnessed, such as the bird strike, however required almost all of the time and attention of DSO and MCO, and precipitated that other smaller issues be temporarily neglected. As the airline continues to grow, the SOC may not have the capacity to address all of the issues that may arise over a short time period if improvements are not made to the SOC's efficiency.

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